REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
16/08/2006	Final	1 May 2004- 30 April 2005

4. TITLE AND SUBTITLE

Space Surveillance Simulator

5a. CONTRACT NUMBER

5b. GRANT NUMBER

FA9550-04-1-0264

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Univeristy of Hawaii

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Office of Scientific Research
4015 Wilson Blvd
Mail Room 713
Arlington, VA 22203
Dr. Jon Sjogren/NM

10. SPONSOR/MONITOR'S ACRONYM(S)

AFOSR

11. SPONSOR/MONITOR'S REPORT

AFRL-SR-AR-TR-06-0409

12. DISTRIBUTION/AVAILABILITY STATEMENT

Distribution A; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The Space Surveillance Simulator is designed to simulate both the atmospheric imaging environment above the Maui Space Surveillance Site (MSSS) on Mount Haleakala, Maui and the adaptive optics (AO) compensation design employed at the MSSS, as well as generic AO approaches with long-term potential. The primary targeted research for this system is the development of advanced methods (both imaging and non-imaging) for surveillance and Space Situational Awareness. In addition to its role as a research tool, the Space Surveillance Simulator also serves as an instructional tool for the education of undergraduate and graduate students and postdoctoral fellows in research topics directly relevant to the mission of the MSSS, and as a precision calibration and testing facility for local researchers involved in Department of Defense related work.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(Include area code)*
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Final Report for AFOSR Award FA9550-04-1-0264
"Space Surveillance Simulator"

P.I. Stuart Jefferies, Institute for Astronomy, University of Hawaii

Executive Summary

The Space Surveillance Simulator is designed to simulate both the atmospheric imaging environment above the Maui Space Surveillance Site (MSSS) on Mount Haleakala, Maui and the adaptive optics (AO) compensation design employed at the MSSS, as well as generic AO approaches with long-term potential. The primary targeted research for this system is the development of advanced methods (both imaging and non-imaging) for surveillance and Space Situational Awareness. In addition to its role as a research tool, the Space Surveillance Simulator also serves as an instructional tool for the education of undergraduate and graduate students and postdoctoral fellows in research topics directly relevant to the mission of the MSSS, and as a precision calibration and testing facility for local researchers involved in Department of Defense related work.

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Overview

The Space Surveillance Simulator is a collection of specialized optical instruments that together provide a system that can simulate both the atmosphere above the Maui Space Surveillance Site (MSSS) on Mount Haleakala, Maui, and the adaptive optics instrumentation in use at the MSSS (see Figure 1). The primary thrust of the research to be conducted with the system is the development of advanced methods (both imaging and non-imaging) for surveillance and Space Situational Awareness. The secondary thrust is to support research on other Department of Defense (DoD) related projects.

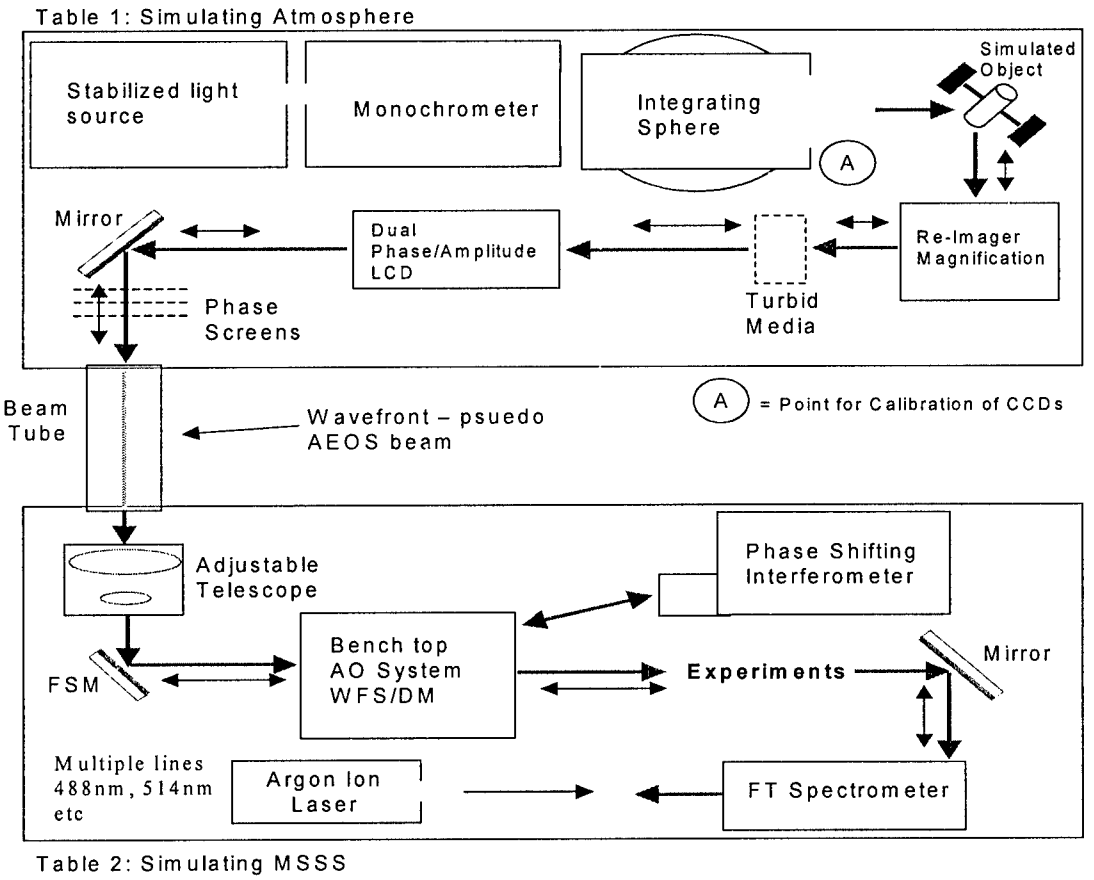

Figure 1. A cartoon that depicts how the individual instruments purchased under the DURIP award combine to form the overall Space Surveillance Simulator system. Abbreviations: AO- adaptive optics, FT – Fourier transform, WFS – wave front sensing, DM – deformable mirror, FSM – fast steering mirror, LCD – liquid crystal device, CCD – charge couple device

Achieving the DURIP Goals

The proposed goals for the Space Surveillance Simulator were to

1. Establish new research capability in support of the mission for the Maui Space Surveillance Site on Maui by providing
    a. An optics research facility where ideas that are being developed under current and future awards from AFOSR/AFRL, can be demonstrated and evaluated. In particular, those related to research into the next generation of techniques for adaptive optics
    b. Basic optics metrology capability
2. Enhance research-related education in areas related to space situational awareness, and to foster the next generation of instrumentation specialists and experimentalists in these areas, by providing
    a. A state-of-the-art optics facility for young researchers (recent PhDs)
    b. Internships for
        i. University undergraduates and graduates
        ii. High school students
    c. Instrumentation for a new course in electro-optics at Maui Community College (MCC)
3. Interface with existing research facilities
    a. On-island, in particular, the Maui Space Surveillance Site
    b. Off-island and on the mainland

The acquisition of the components for the Space Surveillance Simulator was completed by the end of October 2005; however, research projects were being conducted well before this date (e.g., see Figure 2). Table 1 summarizes the activities that have taken place since the arrival of the first components of the system (late Spring 2004) and the end of 2005. We are happy to report that all of the original proposed goals have been addressed, the vast majority with a high level of success. Even in the two areas where the goal has either not been met or only partially met (2.c and 3.a respectively), we are making progress: negotiations are underway with both the faculty at Maui Community College, on how we can incorporate the Simulator into their new course in optics, and with personnel at BOEING and TREX on how closer connections with the MSSS can be established[1].
Important activities that have taken place and that are not reflected in Table 1 are: 1) discussions with the Center for Adaptive Optics[2] (CfAO) on both establishing a collaboration for select AO-related research projects and hosting CfAO interns and graduate students to work at the Space Surveillance Simulator, 2) the granting of an AFOSR award to support travel between facilities involved in AO research to foster closer connections between the different facilities[3], and 3) equipment contributions from other sources (phase screens from the SUBARU project [donated] and a large aperture spatial light modulator from the NRL [on loan]) .
In summary, the Space Surveillance Simulator project is well on track to fulfill its potential as an important resource for enhancing the research capability on Maui, in areas of interest to the DoD, for many years to come.

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[1] Boeing has the primary contract with AFRL/DE to operate all of the AFRL telescopes atop Haleakala on Maui and the Starfire Optical Range in Albuquerque. TREX is the main subcontractor to Boeing to operate and maintain the AEOS adaptive optics system at MSSS,

[2] A NSF Center at the University of California, Santa Cruz, CA.

[3] These facilities include the Starfire Optical Range in Albuquerque, NM and the Steward Observatory at the University of Arizona in Tucson, AZ.

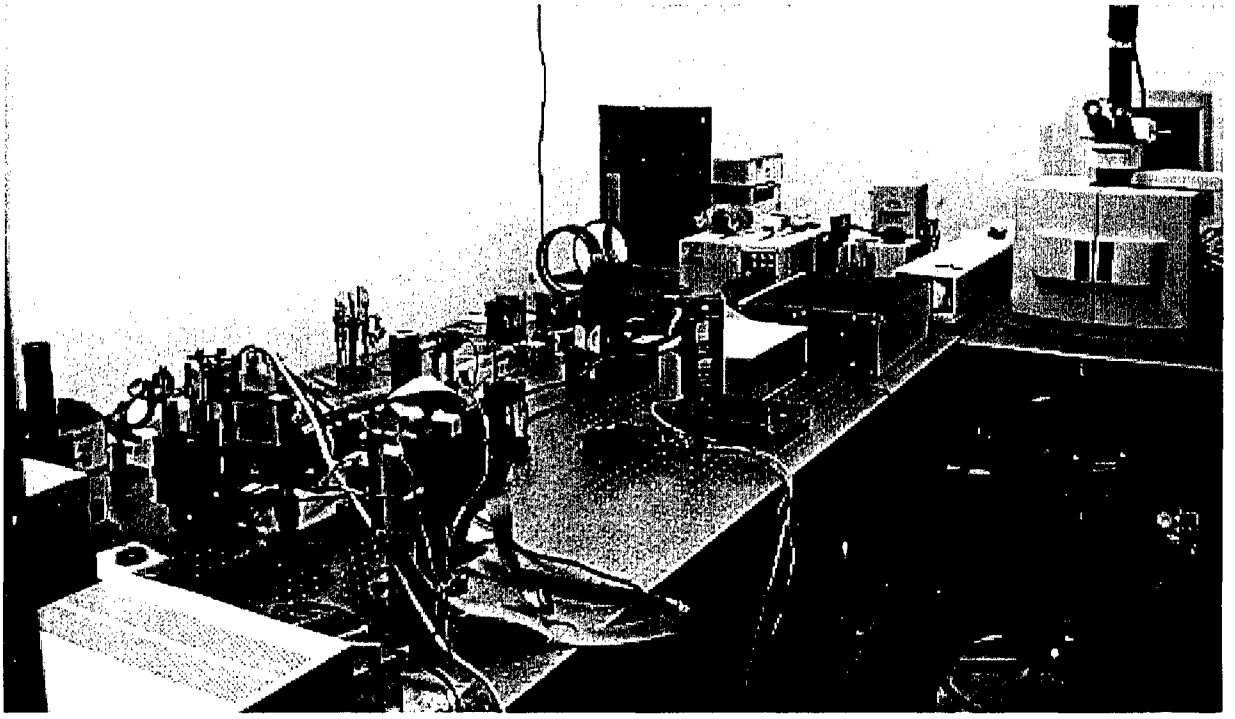

Figure 2. An early experiment in wave front sensing using the Space Surveillance Simulator (January 2005).

Presentations and Publications

1. "Photonic muscles: optically controlled active optics", Joe Ritter, Jim Brozik, Solomon Basame, Mike Fallbach, Larry Bedford, Dennis Douglas and Gilda Miner, in *Advanced Wavefront Control: Methods, Devices and Applications III*, Editors: Mart T. Gruneisen, John D. Gonglewski and Michael K. Giles, **SPIE 5894**, 379-390 (2005).
2. "Evaluations of spectral unmixing algorithms using ground-based satellite imaging", James F. Scholl, E. Keith Hege, Michael Lloyd-Hart, Daniel O'Connell, William R. Johnson and Eustace L. Dereniak, SPIE Defense and Security Symposium in Orlando, FL, April 20, 2006.
3. "Figure of merit calculations for spectral unmixing algorithms", James F. Scholl, Eustace L. Dereniak and E. Keith Hege, SPIE Annual Meeting in San Diego, August 13, 2006.
4. "Hyperspectral feature classification for spectral unmixing algorithms", James F. Scholl, Eustace L. Dereniak & E. Keith Hege, SPIE Annual Meeting in San Diego, August 13, 2006.
5. "Space Surveillance Simulator", Maile Giffin, Daniel O'Connell, Stuart M. Jefferies & Jeffrey Kuhn, poster at the 2004 AMOS Technical Conference in Kihei, HI (September 2004).

Senior Personnel

The Principal Investigator has recently moved institutions from the University of New Mexico to the University of Hawaii. However, both Universities are supportive of the Space Surveillance Simulator project. Co-Investigators, Giffin and O'Connell have moved from Oceanit.

Category	Project	Affiliation	Principal Investigator	Goal addressed
Research: Adaptive Optics	Active optical mirrors based on photoisomerization	Institute for Astronomy, Univ. of Hawai'i	Ritter (*)	1.a
	Large liquid crystal wave front control experiments	Naval Research Laboratory	Restaino	1.a 3.b
	Laser guide star developments	GEMINI Observatory		1.a 3.b
Research: Other	Calibration Improvements to the Computed Tomography Imaging Spectrometer (CTIS)	University of Arizona	Hege	1.a
Education: Graduate level (PhD)	Calibration of CTIS	Univ. of Arizona Jim Scholl (*)	Hege	1.b 2.b.i
	Real-time aperture masking for AO	Univ. of Arizona Sukumar Murali	Tyler	1.a 2.b.i
	Illustration of a closed-loop adaptive optics system	Univ. of Arizona Hari Muralimanohar Sukumar Murali	Tyler	1.a 2.b.i
Education: Graduate level (Masters)	Wave front correction experiments	Univ. of Arizona Dennis Douglas		2.b.i
Education: High School level	Various (including running experiments, and writing software for hardware control)	Maui High School 6 students		2.b.ii
Optics Metrology	Camera calibration	BOEING, OCEANIT	Africano, Gregory	1.b 3.a
	Optical surfaces characterization	Canada-France-Hawai'i Telescope Observatory, GEMINI Observatory, BOEING, Textron		1.b 3.a 3.b
	Filter characterization	BOEING, Univ. of New Mexico	Africano, Armstrong	1.b, 3.a 2.a

Table 1. Summary of the use of the Space Surveillance Simulator during its first year. * Denotes work that has been (or will be) reported in the scientific literature.